Soventix Saldanha 1 & 2 PV power augmentation

Scope 2 - Tier 2 GHG assessment

2020/12/22

Draft 2

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Climate - Disaster - GIS

Independent Power Producers (IPP) that rely on renewable resources for this generation, such as Solar photovoltaic (PV) are subject to a number of factors that will influence generation efficiency. These factors include those within the operators control including PV characteristics, tracking, and those external to operator influence including temperature and cloud cover conditions.

Renewable IPPs are required to ensure there is sufficient power to meet generation commitments made to Eskom and will need to augment a capacity deficit with alterative generation capacity. In order to retain the GHG benefits of renewables, these alternative generation mechanisms will need to generate lower emissions than the PV facility is aiming to mitigate from the Fossil Fuel (FF) grid.

The **purpose of this work** is to therefore assess the GHG emissions from required augmentation in various capacity deficit scenarios.

Delivery

The project consists of two main parts.

Part 1: Assessing the CO_2e saved through developing the PV facility.

- Defining emission scope for FF generation and operations.
- Quantifying CO_2e emission as a factor of MW generation though FF.
- Applying emission factor to CO_2e mitigated through equivalent PV generation capacity over FF generation.

Part 2: Assessing the CO_2e generated thought the augmentation on reduced PV efficiency days.

- Present reduced efficiency scenarios.
- Calculating baseline emissions from augmentation options to Tier 2, scope 2 levels.
- Calculate emission generation in these scenarios.
- Compare CO_2e mitigation vs FF generation.

Version History

Draft 1 – 2020/11/26

- Part 1: complete draft
- Part 2: Efficiency scenarios

Draft 2 – 2020/12/22

- Part 2: replaced emissions with conventional Diesel genset units rather than the specific Gas Turbine generator emissions.

Final version – 2021/03/01

- Received final capacity numbers.
- Calculated net emission benefit.

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Independent Power Producers (IPP) that rely on renewable resources for this generation, such as solar photovoltaic (PV) are subject to a number of factors that will influence generation efficiency. These factors include those within the operators' control including PV characteristics, tracking, and those external to operator influence including temperature and cloud cover conditions.

Renewable IPPs are required to ensure there is sufficient power to meet generation commitments made to Eskom and will need to augment a capacity deficit with alternative generation capacity. In order to retain the Greenhouse gas (GHG) benefits of renewables, these alternative generation mechanisms will need to generate lower emissions than the PV facility is aiming to mitigate from the Fossil Fuel (FF) grid.

The purpose of this work is to therefore assess the GHG emissions from required augmentation in various capacity deficit scenarios.

1. Part 1: Assessing the CO_2e saved through developing the PV facility.

1.1. Defining emission scope for FF generation and operations.

When assessing the potential Carbone Dioxide equivalent (CO_2) mitigation through the development of a PV facility, establishing the baseline for CO_2e through conventional FF generation is the starting point. For this work, the scope of the emissions will be those that result directly from the power generation, fugitive emissions and the transport or raw materials. The emissions from the transport and storage of CO_2 have not been reported by Eskom.

Table 1. IPCC standard GHG generating mechanisms associated with FF based generation.

IPCC emission classification	***Description***	***Gases***	***RSA Public availability data***
1A1a Main Activity Electricity and Heat Production	Cumulation of emissions from electricity generation is to supply the public, combined heat and power generation, and heat plants.		
1A1a -i Electricity Generation	Comprises emissions from all fuel used for electricity generation (excludes combined heat and power plants).	CO_2, CH_4, N_2O, NOx, CO, NMVOC, SO_2	DEA[1]
1A1a -ii Combined Heat and Power Generation	Emissions from the production of both heat and electrical power for sale to the public.		
1A1a -iii Heat Plants	Production of heat from main activity producers for sale by pipe network.		
1B Fugitive Emissions from Fuels	Includes all intentional and unintentional emissions from the extraction, processing, storage, and transport of fuel to the point of final use.		
1B1a Coal Mining and Handling	Includes all fugitive emissions from coal. Including Underground Mines, Surface Mines, Abandoned mines, Post-mining Emissions, Flaring	CO_2, CH_4,	DEA[2]
1B1b Uncontrolled Combustion, and Burning Coal Dumps	Includes fugitive emissions of CO2 from uncontrolled combustion in coal.	CO_2, CH_4, N_2O, NOx, CO,	

[1] Department of Environmental affairs. GHG National Inventory Report to UNFCCC, South Africa, 2000-2015
[2] ibid

IPCC emission classification	*Description*	*Gases*	*RSA Public availability data*
1B1c Solid Fuel Transformation	Fugitive emissions arising during the manufacture of secondary and tertiary products from solid fuels.	NMVOC, SO_2	
1B2 Oil and Natural Gas	Comprises fugitive emissions from all oil and natural gas activities. The primary sources of these emissions may include fugitive equipment leaks, evaporation losses, venting, flaring and accidental releases.		
1B2a Oil	Comprises emissions from venting, flaring and all other fugitive sources associated with the exploration, production, transmission, upgrading, and refining of crude oil and distribution of crude oil products.	CO_2, CH_4, NMVOC	DEA[3]
1b2b Natural Gas	Comprises emissions from venting, flaring and all other fugitive sources associated with the exploration, production, processing, transmission, storage, and distribution of natural gas (including both associated and non-associated gas).		
1C Carbon Dioxide Transport and Storage (CCS)	CO2 capture and storage involve the capture of CO2 from anthropogenic sources, its transport to a storage location and its long-term isolation from the atmosphere.		
1C1 Transport of CO2	This comprises fugitive emissions from the systems used to transport captured CO2 from the source to the injection site. These emissions may comprise losses due to fugitive equipment leaks, venting and releases due to pipeline ruptures or other accidental releases.	CO_2	These emissions are not estimated (NE) in the report[4]
1C2 Injection and Storage	Fugitive emissions from activities and equipment at the injection site and those from the end containment once the CO2 is placed in storage.		
1C3 Other	Any other emissions from CCS not reported elsewhere.		

The reporting of GHG emissions has in South Africa has previously been inconsistent with earlier iterations lacking inventory accuracy and completeness due to the application of lower-tier methods resulting from the unavailability of disaggregated activity data, lack of well-defined institutional arrangements, and absence of legal and formal procedures for the compilation of GHG emission inventories. However, South Africa has recently developed a National GHG Inventory Management System and the National Atmospheric Emissions Inventory System to manage and simplify its climate change obligations to the United Nations Framework Convention on Climate Change (UNFCCC) process. These processes gather activity data and associated emission factors, were not available, model the GHG contribution of all sectors to serve as input for the national inventory reporting process (Figure 1).

[3] Department of Environmental affairs. GHG National Inventory Report to UNFCCC, South Africa, 2000-2015
[4] Activities in the 2015 inventory which are not estimated (NE)

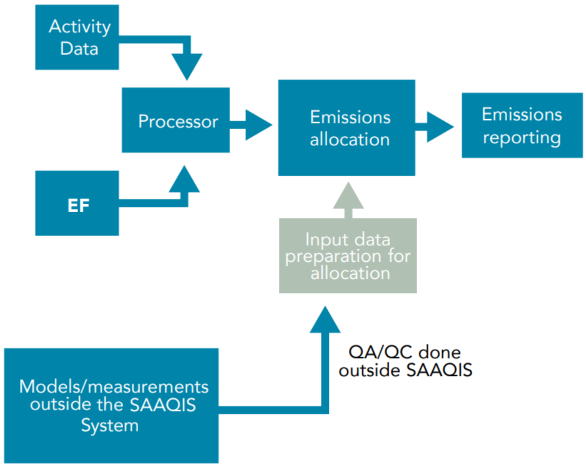

Figure 1. Information flow in South Africa's National Atmospheric Emissions Inventory System.

1.2. Quantifying CO_2e emission as a factor of MW generation through FF.

South Africa's power generation capacity being reliant on FF are highly aligned with the spatial distribution of these resources (Figure 2). As such applying provincial delineation to the power generation through FFs is not a true measure of the potential mitigation benefit. Mitigation is therefore assessed against the national average generation processors.

Figure 2. Spatial distribution of Eskom Power stations in South Africa

Emissions reported to the UNFCCC resulting from the GHG Inventory Management System procedures are used as the emissions baseline for comparison for mitigation actions. These reports are the most accurate and authoritative inventories of GHGs currently publicly available for the energy sector in South Africa.

The energy sector is the largest contributor with 79.5% or 429 907 Gg CO_2e of the total gross emissions for South Africa. This sector is broken down further into energy generation industries (60.4%), Transport (12.6%), Other sectors (11.4%), and Manufacturing industries and construction (8.6%). Since 2000 this sector has increased by 25.0% with the majority of the increase coming in the energy generation industry specifically. This recent increase highlights the need for IPPs to produce renewable energy to mitigate the GHG emissions from the growing needs of the country while endeavouring to meet the UNFCCC GHG commitments.

The GHGs produced and the relative CO_2e estimates from the FF energy generation industry are assessed as per the IPCC standard GHG generating mechanisms below (Table 2).

Table 2. Assessment of gross emissions for South Africa (2015) [5]

	Tons			Emission estimate (Gg CO2e)			
	CO_2	CH_4	N_2O	CO_2	CH_4	N_2O	Total
1.A – Fuel Combustion Activities	397861	22	8				
1.A.1a – Main Activity Electricity and Heat Production	258696	3	4	224009	52	1069	225130
1.B – Fugitive emissions from fuels	25320	173	*NE*				
1.B.1 – Solid Fuels	21	76	*NE*	21	1587	*NE*	1608
1.B.2 – Oil and Natural Gas	642	*NE*	*NE*	642	*NE*	*NE*	642
1.C – Carbon dioxide Transport and Storage	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*	*NE*
							227 380

South Africa's FF power capacity is estimated at 40 036 MW. The power generation processors to reach this capacity are ~227Mt CO_2e per year through the mechanisms of 1A1a, 1B1, and 1B2 (1C is not estimated)[6]. The average emission rate per MW generation capacity is calculated as follows:

$$ER_{ff} = \frac{ET_{ff}}{GenCap_{ff}}$$

Where ER is the Emission rate in (Mt CO_2e)/MW, ET is the Emission Total, GenCap is the Generation capacity, and ff denotes the classification of fossil fuels only.

The resulting emissions to generate a single MW of power through FFs is estimated at 0.0057 MtCO_2e/MW or 5 679.39 tCO_2e/MW per year. This equates to an estimate of 15.56 tCO_2e/MW/day or ~0.65 tCO2e/MW/hour.

1.3. Applying the emission factor to mitigated CO2e through equivalent PV generation.

The PV facilities being developed are as follows:

- Saldanha 1 and Saldanha 2 in Saldanha bay shall be combined into a single facility which intends to feed 55MW into the grid when available during the dispatch period (05:00 to 21:30 every day), and the remaining PV generation capacity will charge battery banks used to augment the required power during the dispatch period. The generators will serve to provide power to meet the required commitment in unforeseen instances when PV generation is unavailable and when the battery banks are depleted.

At optimum capacity and without the need to augment through the generation assurance to meet generation commitments the mitigation potential of the proposed PV facility are as follows.

Location	**Estimated Total PV Capacity**	**Estimated Capacity to the grid**	**Mitigated / year**
Saldanha 1	55 MW	27.5 MW	156.2 t CO_2e
Saldanha 2	55 MW	27.5 MW	156.2 t CO_2e
		55 MW	312.4 t CO_2e

[5] Department of Environmental affairs. GHG National Inventory Report to UNFCCC, South Africa, 2000-2015

[6] ibid

2. Part 2: Assessing the CO_2e generated thought the augmentation for reduced PV capacity.

2.1. Defining reduced efficiency scenarios.

As the renewable IPPs are required to ensure there is sufficient power to meet generation commitments, the utilisation of battery banks charged though the non-grid generated capacity will cover the capacity shortfall in the scenario of inclement weather or any other reason the PV facility is unable to meet the requirement. Further generation assurance is provided by generation facilities at the PV locations. It is anticipated these generators are able to output ~10MW to augment the power supply in unforeseen instances when PV generation is unavailable and when battery banks are not sufficient. The GHG emissions from these generators are assessed over several augmenting scenarios.

- 1MW generation required.
- 2 MW generation required.
- 5 MW generation required.
- 10 MW generation required.

For both Diesel average biofuel blend and 100% mineral diesel fuel types. The emissions from these generation activities are the subject of the IPCC GHG assessment 1A1c standard.

2.2. Calculating Global warming potential from emissions

The GHGs associated with the power augmentation is assessed for these scenarios by applying Scope 2[7] and Tier 2[8] assessments of the Carbon Footprint Process for the generation mechanisms. In instances where augmentation from the Diesel generators is required, the potential assessment of these emissions will be required.

Diesel Genset unit operation

These generators sets or "Genset" units provide energy as a supplementary power source. In this instance, they will be supplementary to the PV and battery pack in place and will be used in unforeseen instances when PV generation is unavailable, and the batteries are depleted.

The fuel efficiency of these generators will be based on a number of factors including temperature/cooling, rpm, generating capacity, and load capacity. Below are the fuel utilisation estimates[9] for different generator sizes operating at different load capacities. What becomes evident is the increased fuel efficiency of larger generators operating at full load capacity, as opposed to the smaller generators, or operating at lower load.

Table 3. Generation capacity vs fuel consumption at different load levels[10]

kW generator	1/4 Load (l/hr)	1/2 Load (l/hr)	3/4 Load (l/hr)	Full Load (l/hr)
100	9.84	15.52	21.96	28.01
500	41.64	70.03	99.93	135.14
1000	81.76	137.79	197.22	269.14
2000	162.02	273.31	391.79	537.15

[7] Direct emissions, from sources owned or directly controlled by Soventix specifically for the power augmentation and any Indirect Electricity GHGs associated with this operation.

[8] Estimated emission calculations of the activities using known emission factors.

[9] Generator Source, Approximate Diesel Fuel Consumption Chart

[10] These values will fluctuate due to variance in heating over time.

The global warming potential (GWP) of running the generators for an hour is calculated through the use of fuel emission factors compared to an equal measure of CO_2 to get Carbon dioxide equivalent (CO_2e). The kg CO_2e generated per hour is given by.

$$Eg_{(kg)} = F_{(\frac{volume}{hour})} * GWP_{(volume)}$$

Where Eg is the mass of the gas emitted in kg, F is the fuel use per hour and GWP is the global warming factor in volume.

Liquid Diesel's Global Warming Potentials (GWP) in CO_2e are 2.61163[11] and 2.67620[12] per litre (l). Each of the generation rates will result in different power generation. The full load utilisation scenario results in the optimum CO2e emission rates per MW generation. This then can be calculated in emissions per hour per MW generated for each of the generator sizes.

Table 4. Estimated CO_2e generation based on GWP for Diesel (average biofuel blend)

kW generator	**1/4 Load**	**1/2 Load**	**3/4 Load**	**Full Load**	**kg CO_2e / hour / MW**
100	25.70	40.53	57.34	73.16	731.57
500	108.75	182.89	260.99	352.93	705.87
1000	213.54	359.85	515.06	702.90	702.90
2000	423.12	713.77	1 023.21	1 402.83	701.42

Table 5. Estimated CO_2e generation based on GWP for Diesel (100% mineral diesel)

KW generator	**1/4 Load**	**1/2 Load**	**3/4 Load**	**Full Load**	**kg CO_2e / hour / MW**
100	26.34	41.54	58.76	74.97	749.66
500	111.44	187.41	267.45	361.66	723.32
1000	218.82	368.75	527.80	720.28	720.28
2000	433.59	731.42	1 048.51	1 437.52	718.76

2.1. Calculating emissions from augmentation scenarios

Applying the estimated kg CO_2e / hour emissions to the potential generation scenarios, the hourly emissions rise as a function of the required generation capacity below. The 1000kW generator Genset is used for these calculations as the most likely cost-effective and efficient solution utilised.

Table 6. Estimated CO_2e generation based on GWP for the four generation scenarios.

		GWP (t CO_2e / hour)	
Scenario	Fuel use (l / hour)	Diesel (average biofuel blend)	Diesel (100% mineral diesel)
1 MW generation	269.14	0.702	0.720
2 MW generation	538.29	1.405	1.440
5 MW generation	1 345.71	3.514	3.601
10 MW generation	2 691.43	7.029	7.202
100% contracted capacity 55MW	14 802.85	38.66	39.62
100% contracted capacity 55MW for the full day[13]	244 246.96	637.88	653.65

[11] Diesel (average biofuel blend) - Standard diesel bought from any local filling station (across the board forecourt fuel typically contains biofuel content).
[12] Diesel (100% mineral diesel) - Diesel that has not been blended with biofuel (non-forecourt diesel).
[13] Assuming 05:00 to 21:30

2.2. Compare CO_2e mitigation vs FF generation.

As calculated in part 1 of the assessment the emissions resulting from generating a single MW of power through FFs is estimated at 5 679.39 tCO2e/MW per year. This equates to an estimate of 15.56 tCO2e/MW/day or ~0.65 tCO2e/MW/hour or 648.33 kgCO2e/MW/hour. This and the 1MW generation emissions are shown below.

Table 7. Estimated CO_2e cost for FF vs augmented diesel generation.

Generation from FF (kgCO2e/MW/hour)	**Generation from diesel turbine**	
	Diesel (average biofuel blend) (kgCO2e/MWh	Diesel (100% mineral diesel) (kgCO2e/MW
648.33	702.90	720.28
difference	+54.57	+71.95

PV shortfall generation assurance through augmentation by diesel generation is less efficient from a low emissions perspective than the at scale generation from FF generation. The diesel generators produce 54.57 and 71.95 (Diesel average biofuel blend and 100% mineral) additional kgCO2e/MW/hour than the FF option. However, for each hour where the facilities are supplying the required capacity commitment through the PV cell or the battery banks, 648 kgCO2e are mitigated.

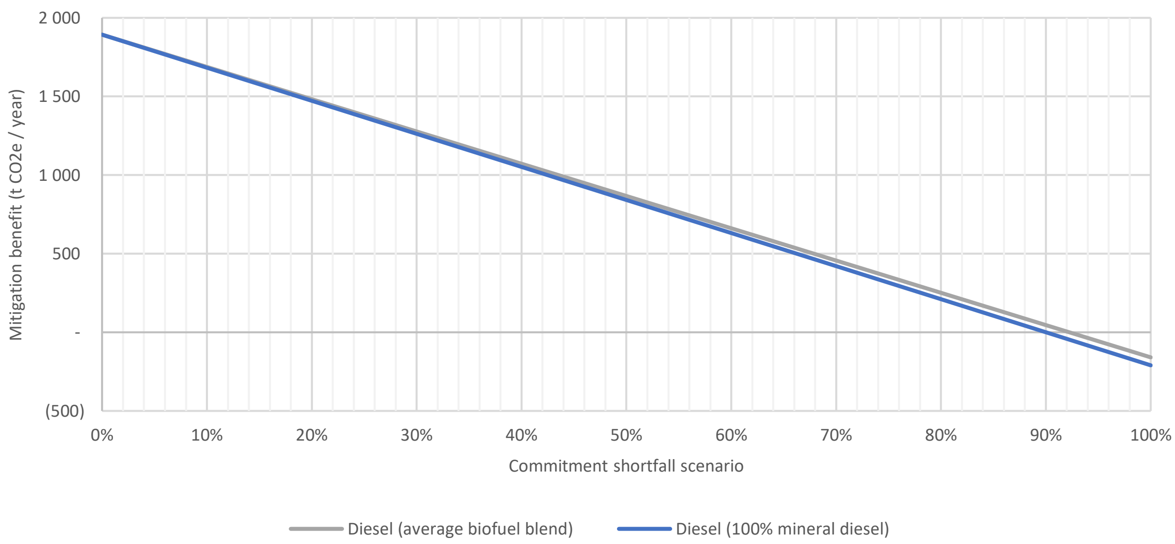

Figure 3. Estimated Mitigation benefit under various commitment shortfall scenarios[14]

The diesel Genset emissions are higher than the emissions from FF generation, it is therefore not a feasible option to replace FF generation in isolation. However, the way it is designed, the battery backup will be charged with the additional generation capacity each day and this will be the first backup augmenting the PV generation during the dispatch period. The generators will serve to provide power to meet the required commitment in unforeseen instances when PV generation is unavailable and when the battery banks are depleted. It is therefore less likely that the generators will be utilised often.

The diesel generator emissions are only between 8 and 11% higher per MW. The emission cost benefit from the generator use over normal fossil fuels is therefore estimated to be at ~90% commitment shortfall from both the PV and battery backup (Figure 3). A shortfall of this magnitude would, however,

[14] Assuming an 8-hour operating day and 365 days a year

be extremely unlikely under normal operations. Reaching commitments above this threshold either through direct power from the PV or the battery bank will result in a net emissions benefit. It, therefore, remains feasible from a GHG perspective to use diesel generators as a backup to the PV and battery bank commitment shortfall.